US Army Corps of Engineers®

# Net-Zero Energy (NZE) Installations & Deployed Bases 2-Day Workshop

## Session V: Energy Conservation for NZE Buildings

**Colorado Springs,
February 3-4, 2009**

# Session V
# Energy Conservation for NZE Buildings

1. Alexander Zhivov, ERDC: "Energy Conservation Technologies for NetZero Buildings"
2. Scot Duncan, ROI-engineering: "HVAC system energy consumption reductions  and energy efficient design strategies for the heating and cooling of buildings"
3. Alan Gillan and Valeriy Maisotsenko, Coolerado: "M-Cycle beyond Comfort Cooling“
4. John Shoner, ORNL: Heat Pump Optimization
5. Gert Brunining, Philips: Advanced lighting systems

US Army Corps of Engineers®

# Session V

# Energy Conservation Technologies for NetZero Buildings (Load Reducing Technologies)

**Dr. Alexander Zhivov**
US Army Corps of Engineers
Engineer Research and Development Center
Champaign, IL

Presented at
**Net-Zero Energy (NZE)**
**Installations & Deployed Bases**
**2-Day Workshop**
Colorado Springs,
February 4, 2009

# Current Army Building Energy Requirements

- The 2005 Energy Policy Act requires that Federal facilities be built to achieve at least a 30 percent energy savings over the 2004 International Energy Code or ASHRAE Standard 90.1-2004 as appropriate, and that energy efficient designs must be life cycle cost effective.
- All SRM Projects for major renovations of existing and new Army facilities shall comply with the requirement of EPACT 2005 to reduce energy consumption by 30% compared to a facility designed in accordance with ASHRAE 90.1-2004 (UFC-3-400-01).
- Building modifications are classified as a major renovation if the cost of renovation project exceeds 25% of the building value with the project including all or some of the following elements: alteration of overall features of the building's envelope, substantial replacement of the building's lighting, plumbing, electrical, and heating, ventilating, and air conditioning (HVAC) systems in combination with other significant alterations of the building's spaces.

# EISA 2007

New buildings and buildings undergoing major renovations shall be designed so that consumption of energy generated offsite or on-site using fossil fuels is reduced, as compared with such energy consumption by a similar building in fiscal year 2003 (as measured by Commercial Buildings Energy Consumption Survey or Residential Energy Consumption Survey data from the Energy Information Agency), by the percentage specified in the following table (EISA 2007):

| Fiscal Year | Percentage Reduction |
|---|---|
| 2010 | 55 |
| 2015 | 65 |
| 2020 | 80 |
| 2025 | 90 |
| 2030 | 100 |

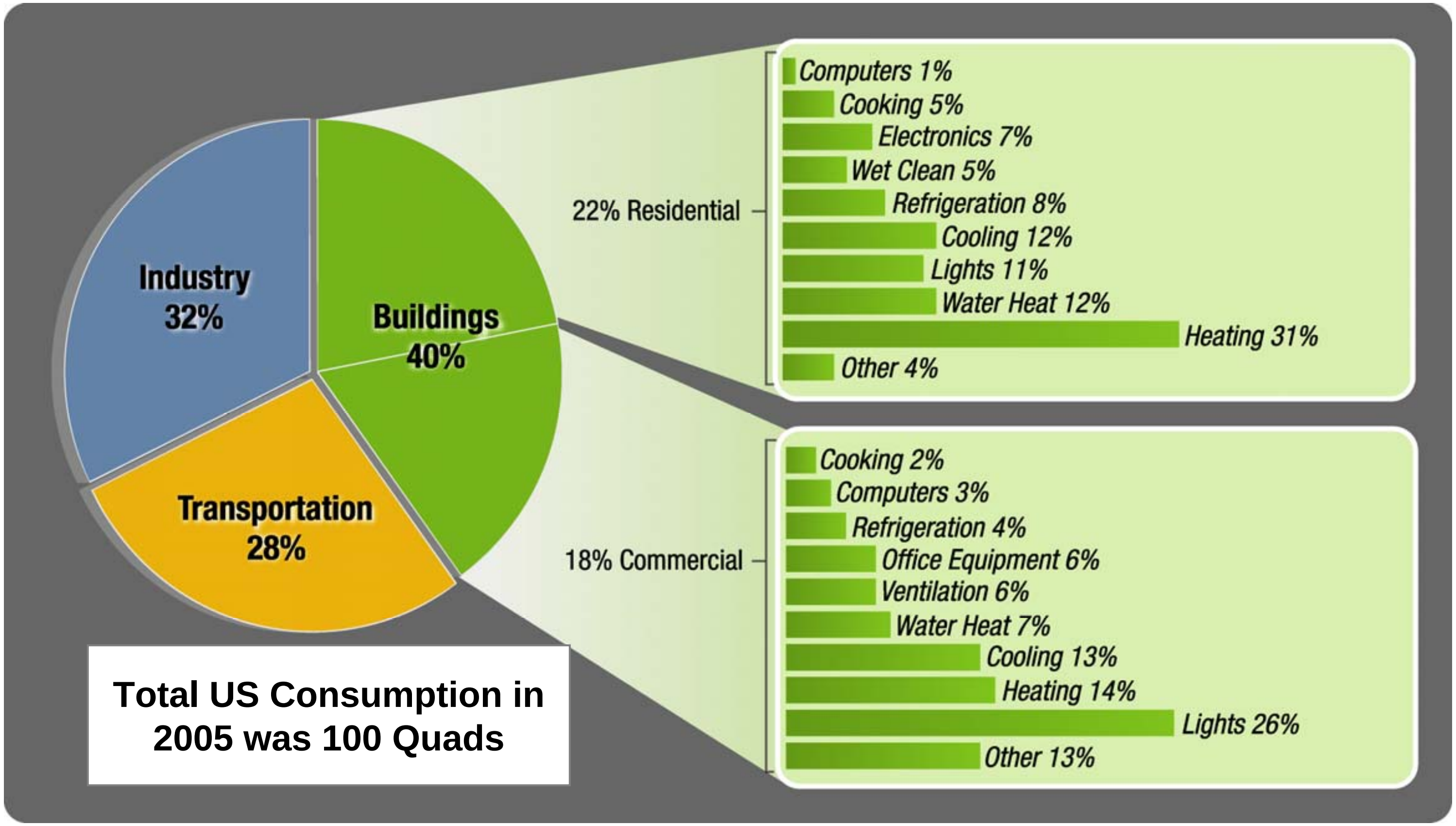
FEMP is drafting a ruling providing interpretation of EISA 2007.

Whatever interpretation will be, by 2030 newly constructed buildings and buildings after major renovations shall be **NZEB**

# How we can get from where we are now to NZEB in 21 years???

- Buildings we are constructing to-day with the requirement to be 30% more energy efficient compared to ASHRAE Std. 90.1 will be there in 21 years and probably be less efficient than they are now (with a current level of maintenance and no re-commissioning)
- ESPC projects addressing only low hanging fruit (improved efficiency of lighting, electrical, HVAC systems, controls, BEMSs..), will fail to reduce energy consumption at a current rate (not mentioning the rate required by EISA 2007) and will become less economically attractive
- Meeting EISA 2007 goals will require:
  - Development of holistic energy systems concepts and applying them through advanced installation-wide energy master planning
  - Setting new more stringent energy targets for new construction and SRM projects executed today with future goals in mind
  - Executing renovation projects by building clusters with a potential to integrate these clusters into the low energy community/installation.
- This approach requires early adoption and application of advanced technologies in new construction and retrofit projects, and a holistic approach and commitment form all stakeholders (planning, financing, PM, design, construction, O&M, building users, owners and managers.)

# Buildings Sector Aaccounts for About 40% of US Energy, 72% of Electricity, 55% of Natural Gas.




**Source: B*uildings Energy Data Book*, September 2007, Tables 1.1.3, 1.1.6, 3.1.1, 3.3.1, 4.1.5, 5.1.2, 5.3.1**

# Major Energy Users

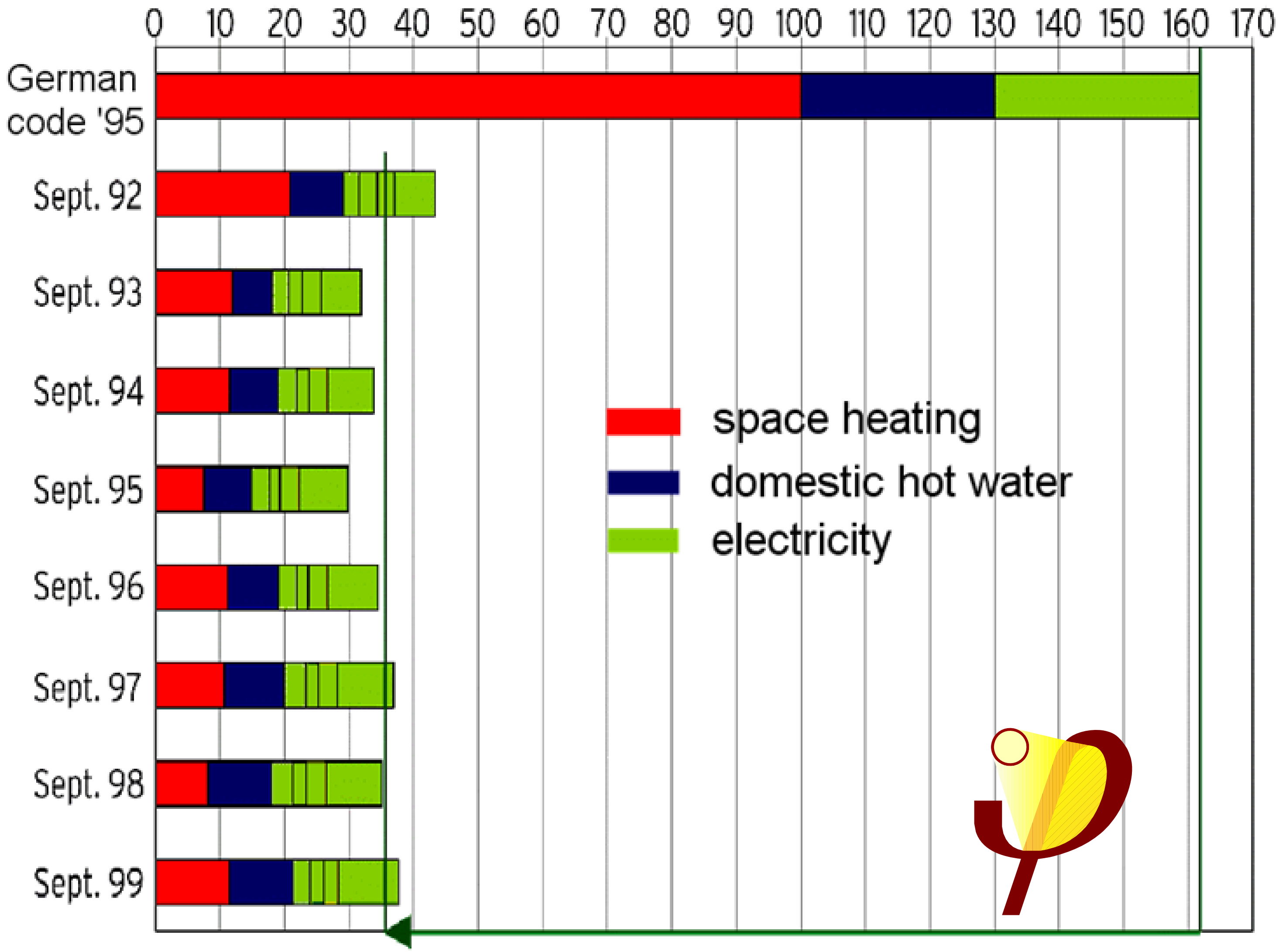
- Lighting
- Heating
- Cooling
- Dehumidification
- Domestic hot water
- Building Processes (e.g., data centers, training facilities, dining facilities, hospitals, etc), and
- Appliances (refrigerators, dryers)

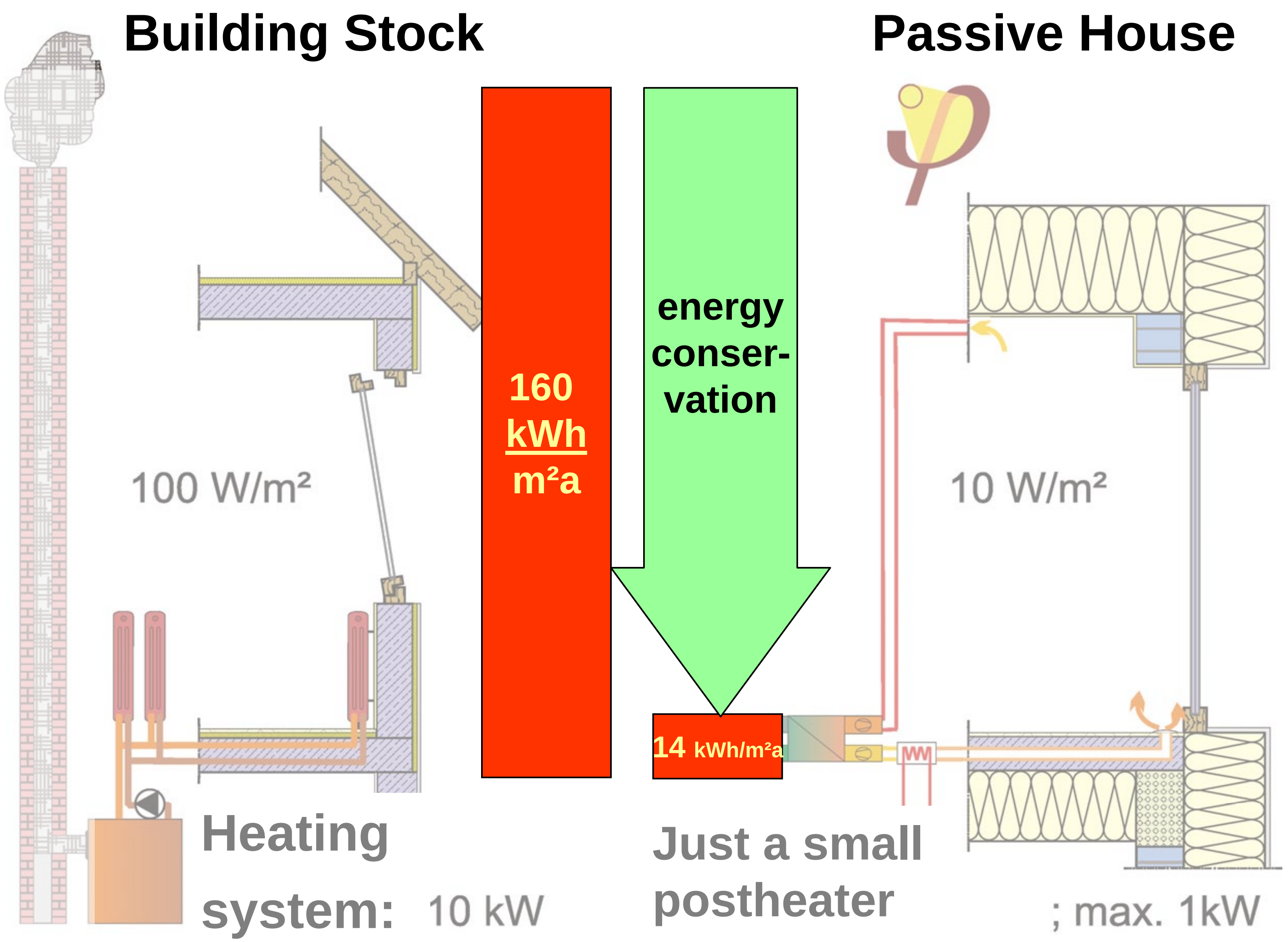
# Where are boundaries between energy conservation and renewable energy application ?

- USACE/DOE/ASHRAE Study showed that 30-35% energy reduction from the ASHRAE 90.1 2004 level can be achieved by using currently available technologies and best design and construction practices at no or minimal additional cost (< 2%);
- In Central Europe, energy reduction in residential buildings up to 90% was achieved in more than 10,000 buildings by using better insulation, airtight building envelope, triple-pane low-e energy efficient windows, energy recovery from exhaust air, advanced lighting and appliances, advanced district systems with cogeneration at a first cost increase < 10%;
- In North American climates, energy reduction beyond 35% (up to ~70%) in addition to European technologies requires **advanced cooling and dehumidification technology**. Main contributor to increased cost are advanced windows, lighting, advanced appliances.
- Between ~70% and 100% of fossil fuel reduction will require the use of central systems with integrated renewable sources of energy and thermal and electrical storages.

# Beyond 30% Energy Improvement

Between 1992 and 2008 more than 10,000 passive houses (< 10KWh/m$^2$yr thermal energy) were constructed in Germany, Austria, Sweden, Italy, USA…



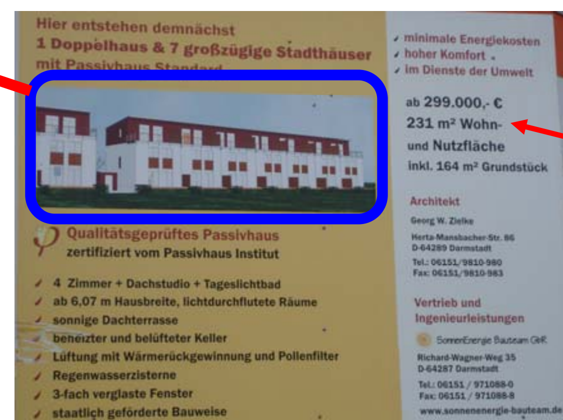


Building Stock
Passive House
160 kWh m²a
energy conser-vation
100 W/m²
10 W/m²
14 kWh/m²a
Heating system: 10 kW
Just a small postheater
; max. 1kW

# Examples of Passive Houses

„Passivhaus“ multifamily blocks Darmstadt, 2007 (above) and 2008 (right)

**Integrated building refurbishment: 38 kWh/m² primary energy consumption** (Volkswohnung, 2002)



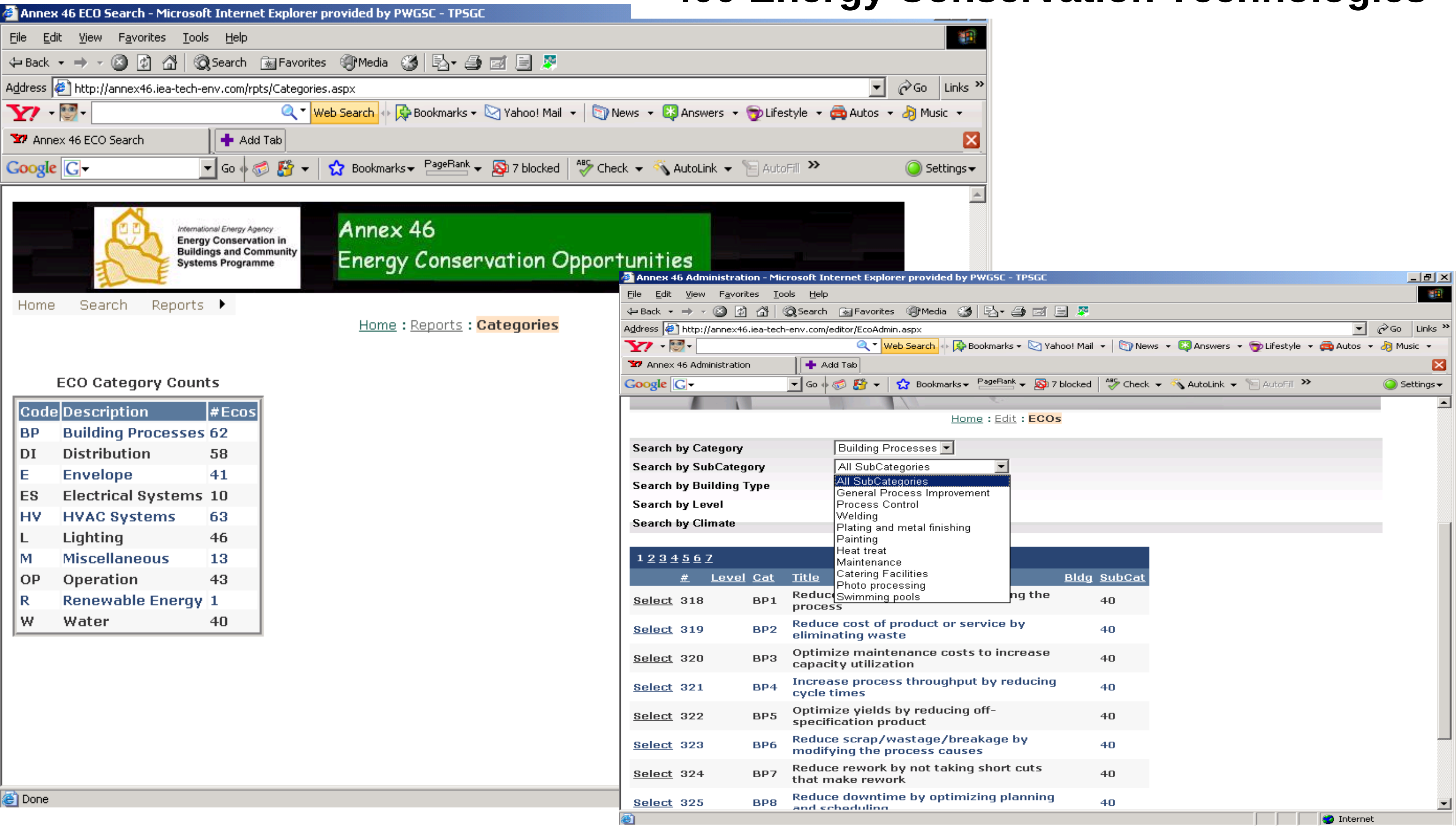

**146 $/ft²**

Total budget increase < 10%

# Some Technologies for
# Low Energy Buildings

# Energy Conservation Technologies

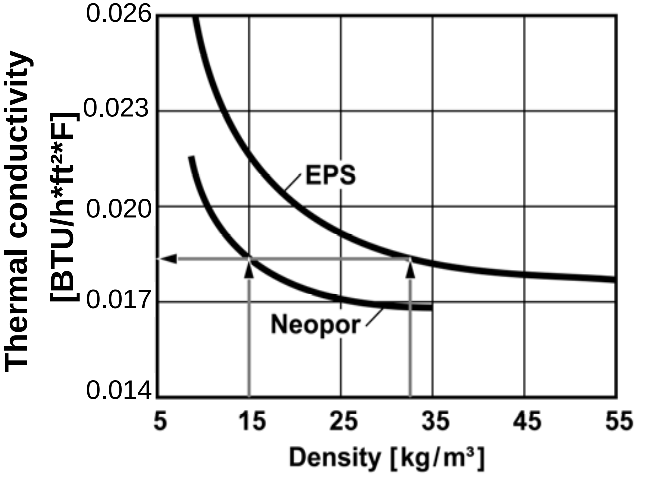
## ~400 Energy Conservation Technologies




http://annex46.iea-tech-env.com

# Examples of Advanced Building Envelope Insulation

**Higher insulation thickness/lower thermal conductivity:** mineral wool/polystyrene with thermal conductivity  of 0.030/0.035 instead of “regular” 0.040 W/mK




**Graphite embedded EPS**
- reduction of the radiant heat transfer
- reduction of the conductivity by 20 %

**Vacuum insulation systems**

# BE Insulation: Cost-benefit Analysis

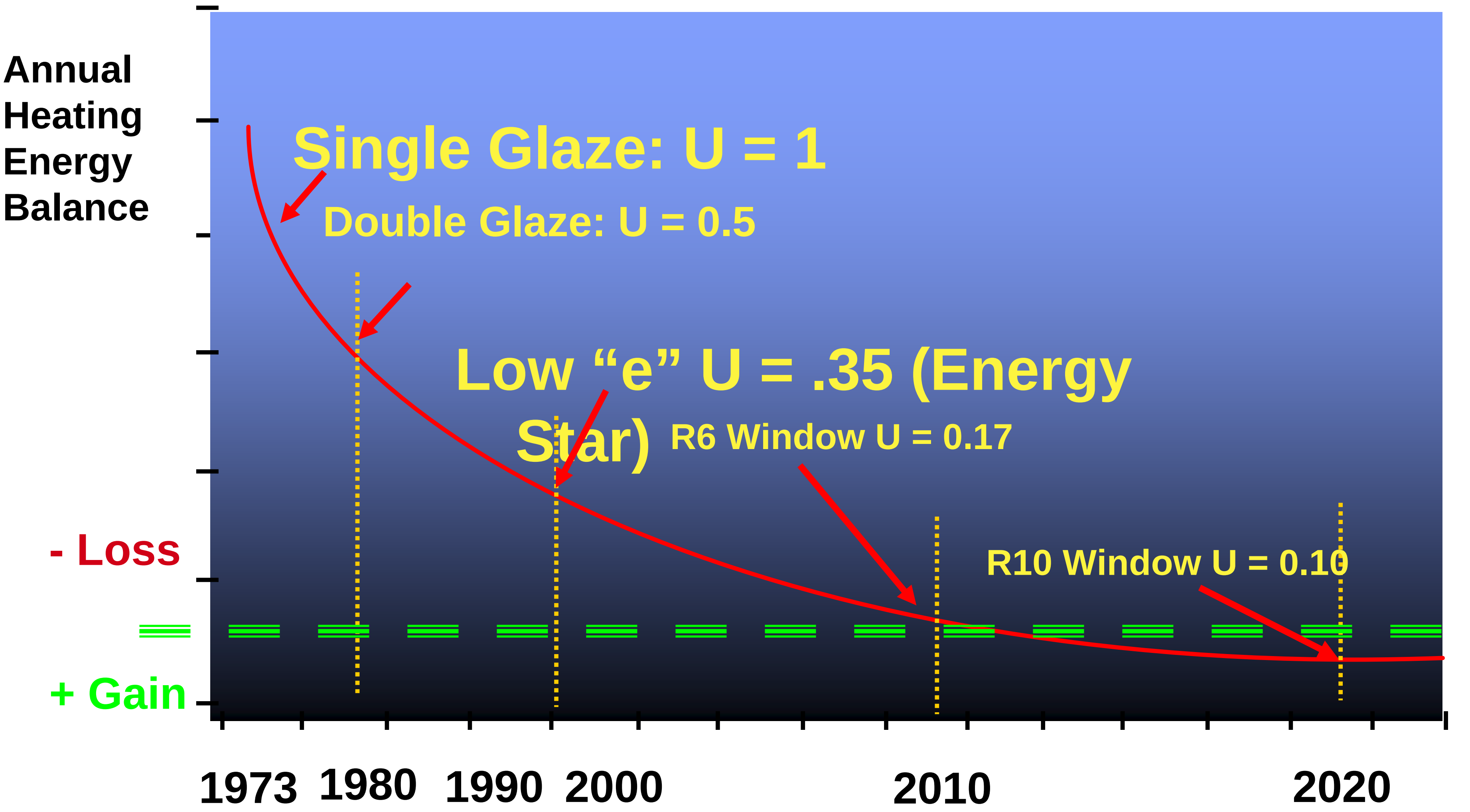
(usage period: 20 years) FI BP presentation in Chicago, 2009)

| Innovative system | Average costs for the saved energy in 20 years [ €/kWh ] |
|---|---|
| Higher insulation thickness* | 0.08 |
| Graphite embedded EPS** | 0.12 |
| High performance plaster systems** | 0.63 |
| Vacuum insulation systems** | 0.20 |
| Light wedges*** | 0.12 |
| Transparent insulation material** | 0.35 |
| Solar walls**** | 0.03 |

* compared to thickness according to requirements
** compared to conventional insulation material of same thickness
*** electrical lighting savings
**** used as preheating of a ventilation system, calculated without extra costs for mech. ventilation systems

For comparison: gas: 0.08 €/kWh; district heating: 0.06/kWh; (consumption related costs only)

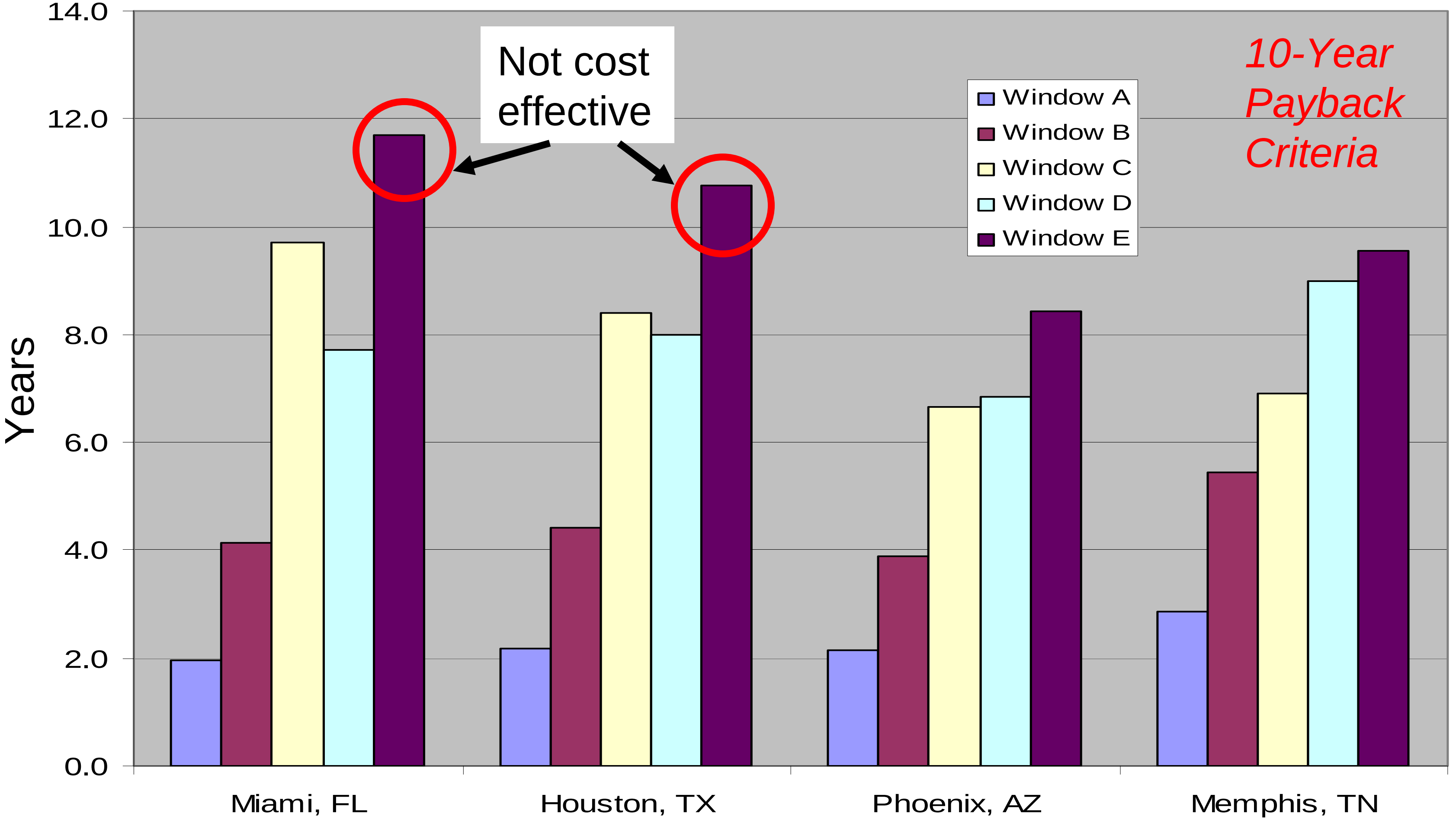
# Advanced Windows
# (LBNL presentation in Chicago, 2009)



## New Construction and Major Renovation or Repair Project

**Modeled payback results - upgrading to premium quality replacement windows vs. current baseline quality replacement windows**

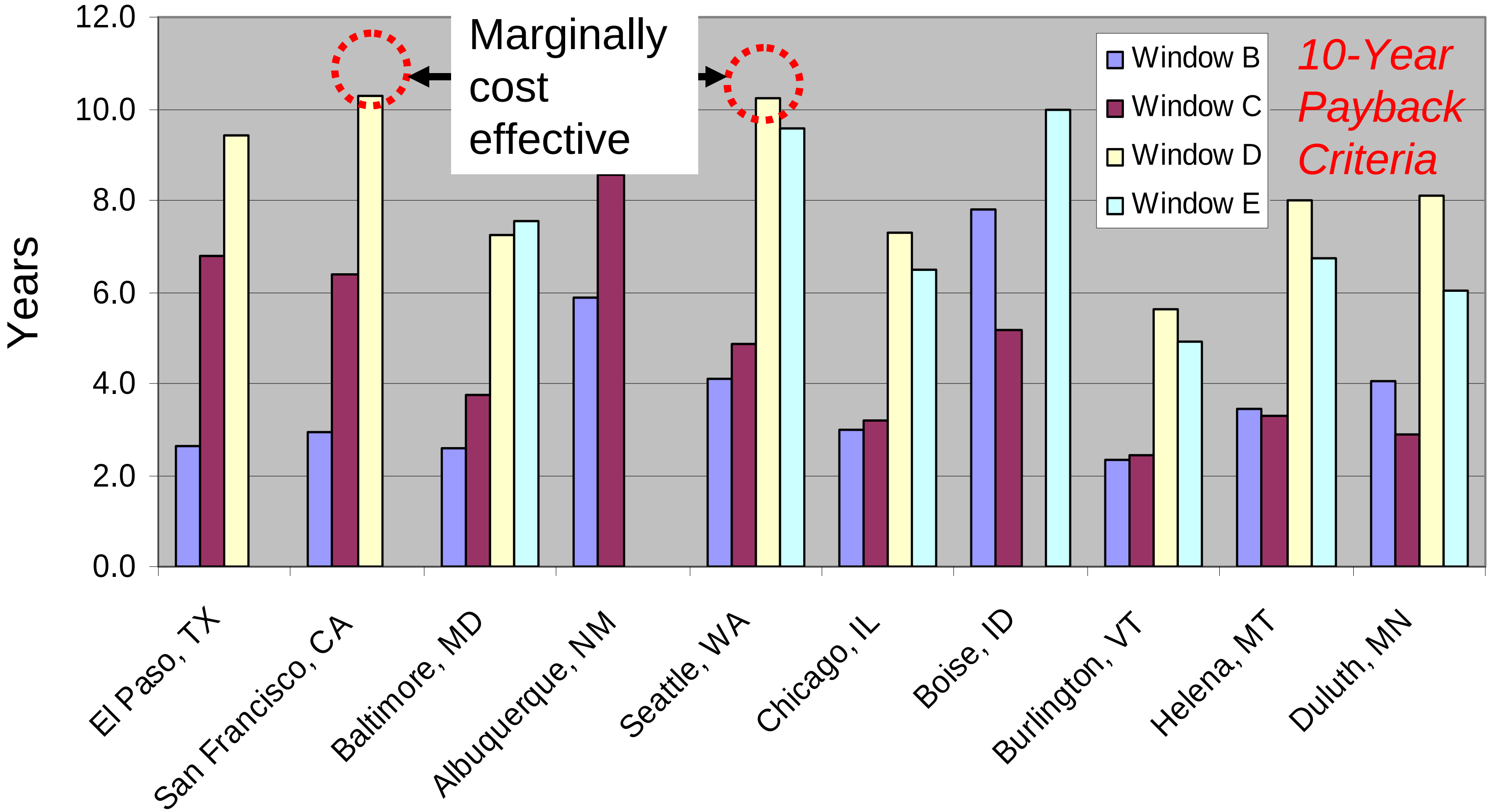
**(Zones 1A, 2A, 2B, and 3A)**



# New Construction and Major Renovation or Repair Project

**Modeled payback results - upgrading to premium quality replacement windows vs. current baseline quality replacement windows**

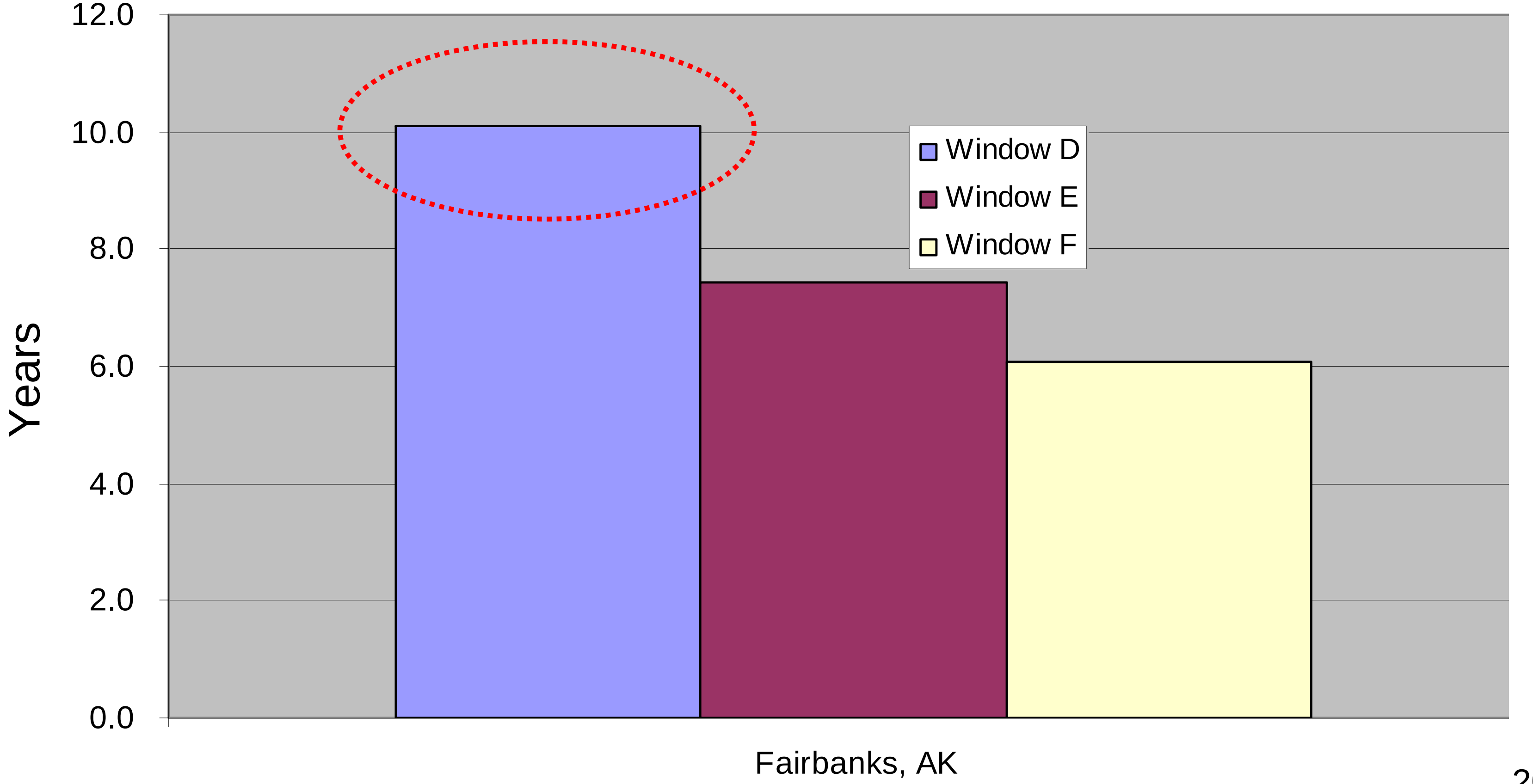
**(Zones 3B, 4A, 4B, 4C, 5A, 5B, 6A, 6B and 7A)**



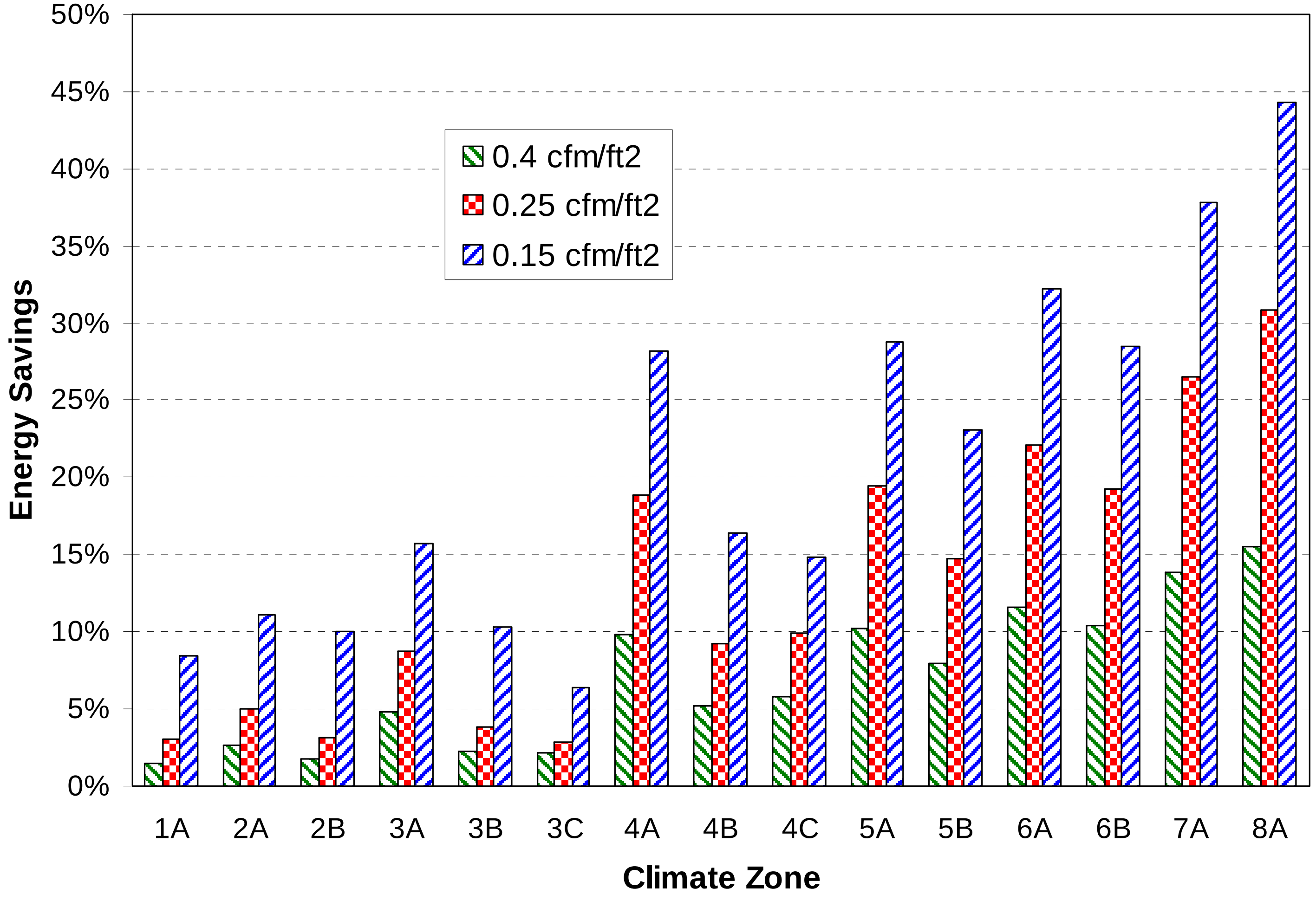
# New Construction and Major Renovation or Repair Project

**Modeled payback results - upgrading to premium quality replacement windows vs. current baseline quality replacement windows**

**(Zone 8)**

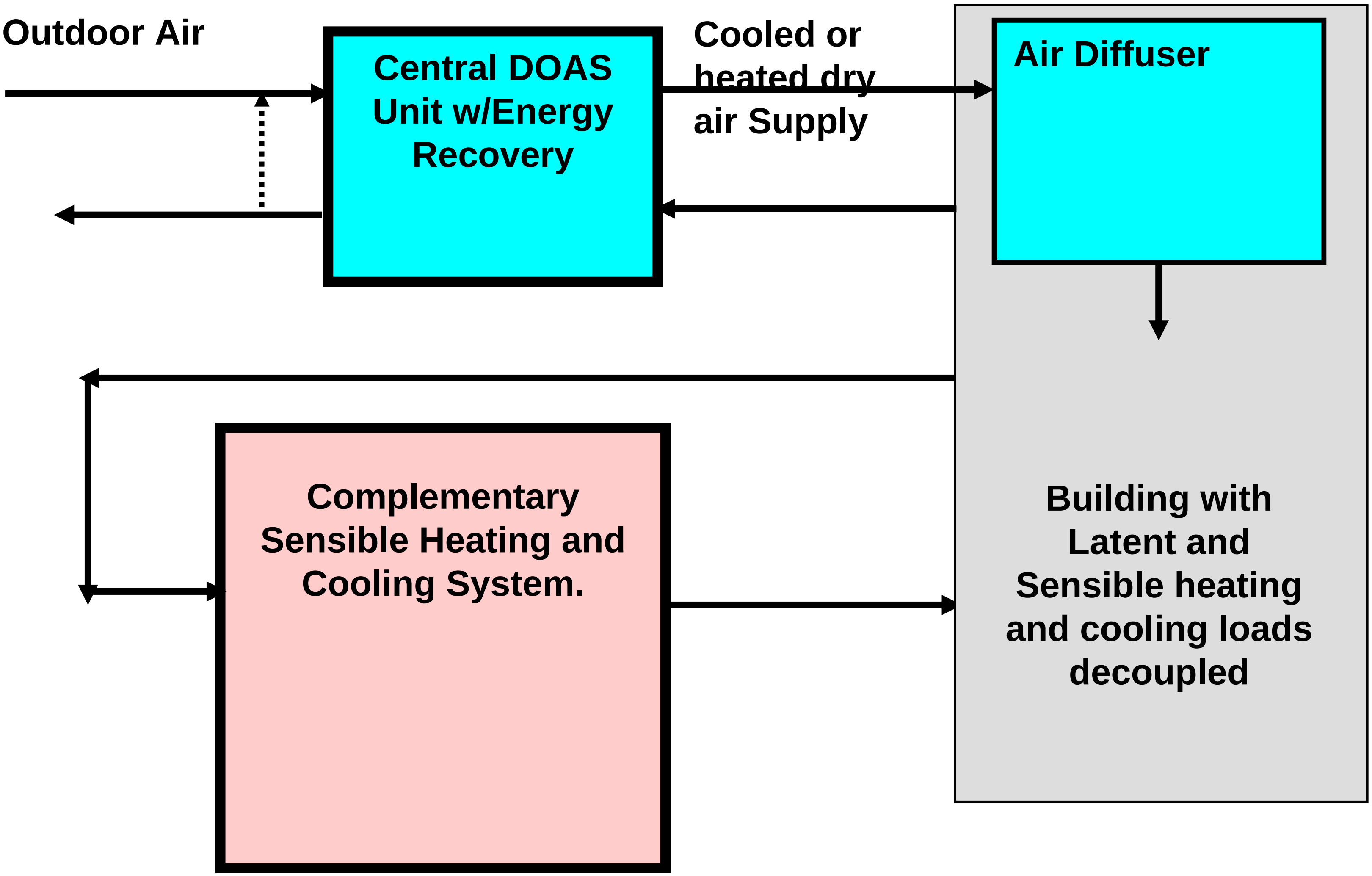


# Annual Energy Savings in Barracks due to Increased Airtightness

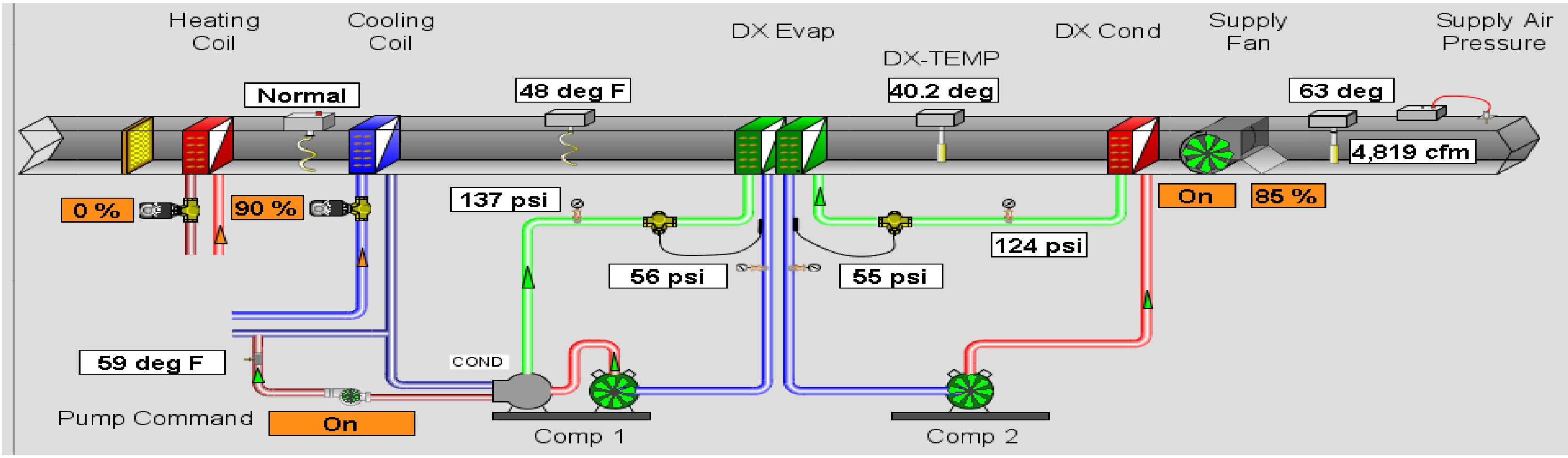


# Low Exergy Heating and Cooling

# Dedicated Outdoor Air System Schematic



# DOAS: DX Dehumidification/Reheat System Added to a Standard Commercial AHU

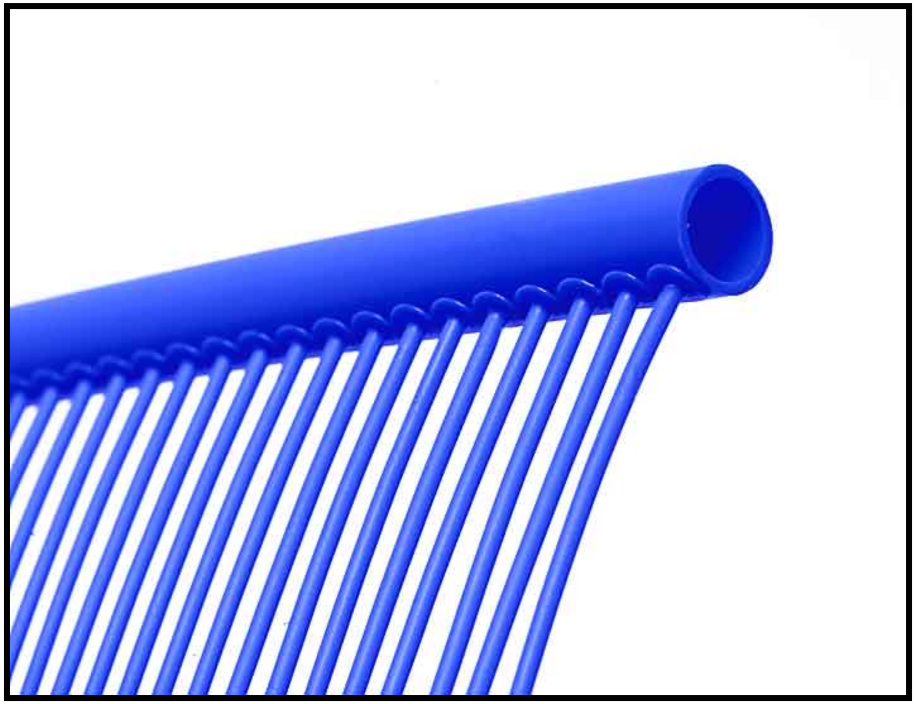




•DX dehumidification/reheat system added to a standard commercial AHU, connected to existing ductwork.

# Radiant Heating/Cooling System

**Installation of the capillary radiant heating/cooling system on the pre-finished surface**



**Two-side cooling mat detail with water feeding (or water return)**

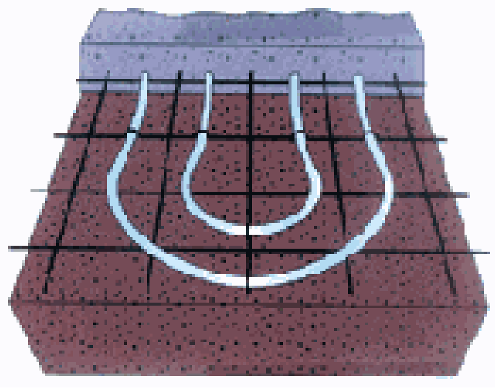
# Radiant Heating/Cooling System

- The chilled ceiling can provide capacity up to 25 Btu/sq.ft. This capacity is generally sufficient if the building is sufficiently insulated and has a DOAS
- Pipes and fittings are made out of polypropylene (plastic). Cooling and heating by Capillary Tubes is not new to the HVAC industry. It was used for commercial and institutional projects over Europe since last fifteen years. Has at least 2 suppliers BEKA, USA and KaRo. See www.beka-klima.de for list of completed projects.
- The capillary tubes (material only) for drywall/plaster or concrete is around $6.00/sq.ft. Additional $ 8.00/sq.ft. will be for installation.

# Low Temperature Hydronic Radiant Heating System


**WAAF – Hangar 1035**
**FRENGER high efficiency radiant panel**

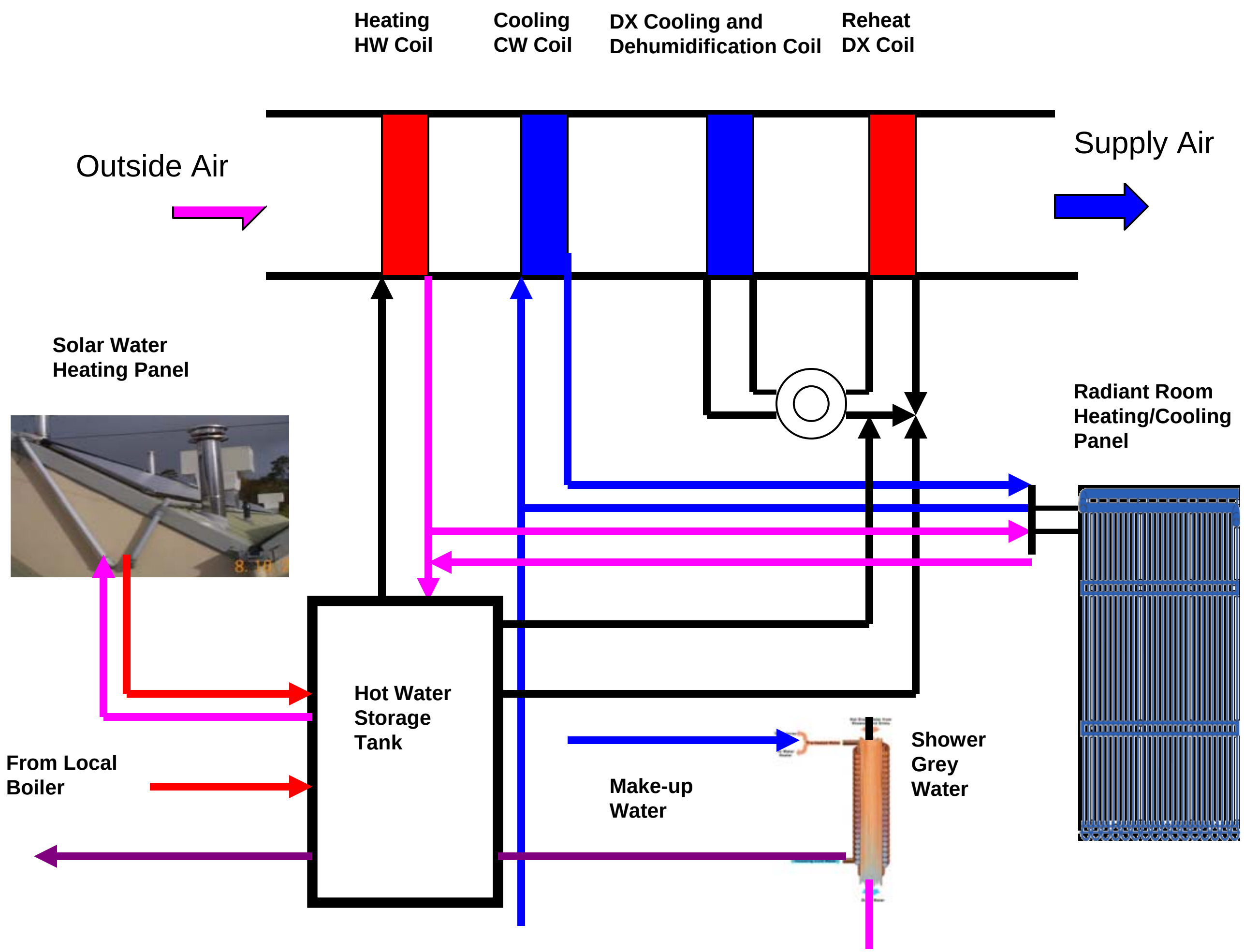
# Low-Intensity Radiant Floor Heating/Cooling



Ft. Lewis

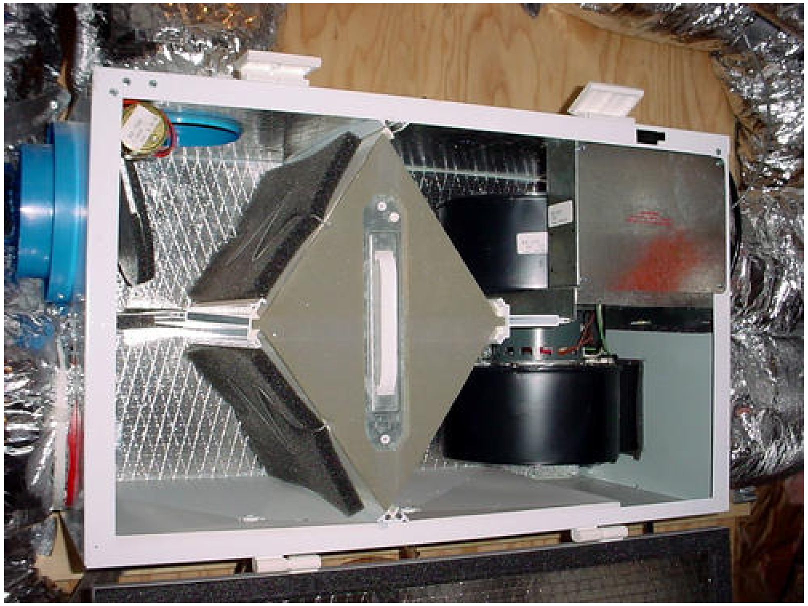

Ft. Drum

# Barrack Energy Efficient Heating and Cooling Concept



# Heat Recovery from Central Exhaust

- Consolidate bathroom exhausts
- Install heat exchanger to recover heating and cooling energy (winter/summer) to pre-heat/pre-cool OA (for the DOAS)



# Keyless Entry Technology Can be Used to Save Energy by lighting, plug-in loads and HVAC system

## Step 1

**Install Keyless Lock**

**Soldier Suite at AG Grafenwoer**

## Step 2

**Add Key Jacket connected to lights and non-critical sockets**

**Key Jacket at the typical hotel room in Europe**

# NZE Building or NZE installation/community?

- Energy use reduction in buildings is feasible and economical. Depending upon the energy cost and climate, existing and advanced technologies and design strategies can reduce energy consumption up to 80-90% with an increased first cost < 10%
- German experience shows that with the current energy costs, even residential NZE buildings are not yet economical
- However, low energy/NZE communities are feasible with a reasonable payback. They require optimization of the building envelope and systems for each building and building clusters
- While low energy or “passiv hous” technologies and design strategies for residential buildings are a common practice in European countries, holistic approach required to develop NZE building communities with a diverse sets of buildings, is still in the stage of the “art”. Optimization of building loads, building and community systems with a consideration of different low and high quality energy sources and waste streams, thermal and electrical storage systems requires further studies.

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# Questions or Comments ?

## Contact Information

**Dr. Alexander Zhivov: + 1 217 373 4519**

**US Army Corps of Engineers**

**Engineer Research and Development Center**

**Construction Engineering Research Laboratory**

**Energy Branch**

**Alexander.M.Zhivov@erdc.usace.army.mil**